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Contact and repellency activities of ethanol extracts from twenty medicinal plants against *Rhizopertha dominica* (Fab.) (Coleoptera: Bostrichidae)

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Abstract: In this paper we reported the bioactivities of ethanol extracts from 20 medicinal plants against *Rhizopertha dominica* (Fab.) using drug-film method and filter paper diffusion method. The results of the contact tests showed that the extract of *Trigonelia foenum-graecum* was most effective on the pest, followed by *Cnidium monnieri* and *Acorus gramineus* respectively. At 0.39 mg/cm^2 treatment, *T. foenum-graecum* extract showed 100% mortality at 48 h post-treatment. *C. monnieri* and *Aconitum carmichaeli* had marked repellence effect against *R. dominica*. *C. monnieri* extract had better contact and repellence efficacy. The LD$_{50}$ of *T. foenum-graecum* plant extract against *R. dominica* after 72 h treatment was 19.94 μg/cm^2.

Key words: Plant extract; contact toxicity; repellency; *Rhizopertha dominica* (Fab.); *Trigonelia foenum-graecum*

At present, the control of stored-product insect populations is primarily dependent upon chemical insecticides, such as methyl bromide and phosphine. The repeated use of chemical insecticides for several decades has disrupted biological control by natural enemies, led to outbreaks of insect pests, widespread development of resistance and undesirable effects on non-target organisms, and fostered environmental and human health concerns (Champ and Dyte, 1977; Hayes and Laws, 1991; Subramanyam and Hagstrum, 1995; White and Leesch, 1995). Environmental Protection Agency of USA in 2001 had proposed elimination of the production of methyl bromide in the USA by 2005 owing to its ozone depletion potential. Owing to the abundant unreasonable application of chemical pesticides, 3R (resistance, resurgence, and residue) problem has aroused wide attention among researchers. Therefore, seeking and exploring new types of botanical pesticide in natural plant has becoming the focus for research. At present, some stored-product insect pests are found to have developed resistance to phosphine (Cao *et al*., 2003; Cao, 2005). These problems have highlighted the need for the development of new types of selective insect-control alternatives. While actively developing new types of formulation on the traditional chemical pesticides, the researchers are exploring the new types of pesticides possessing good effect and being safe to environment.

Plants contain abundant bioactive chemicals that may provide potential alternatives to currently used pest-control agents (Wink, 1993). Utilizing the plant that can be used to control pest, analyzing its active constituent, and seeking the natural lead compound that can be synthesized, then synthesizing the new pesticide by imitating the model, become an ideal approach to explore new pesticides (Arnason *et al*., 1989; Miyakado *et al*., 1989; Isman, 1995; Hedin *et al*., 1997). Plants have many mechanisms for resisting the attack of harmful organisms, which not only include the plant's conformation and behavior, but also its secondary metabolic substances. The plant's secondary metabolic substances usually are the compounds having the bioactivity to pest, which have obvious suppressant action including antifeedant efficacy, repellence, antigonadal activity, contact toxicity and stomach poisoning etc. There are approximately 250 000 known plant species all over the world, yet only 10 percent of the plants were studied on chemistry composition. It has been reported that there are more than 2 400 plants having the bioactivity to control harmful organisms. Studying the active constituent and then synthesizing novel pesticide have become the emphasis on exploring new type of pesticides (Shi and Xu, 1997; Zhang, 1999).

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R. *dominica* is a key primary pest of stored food, and may make a great loss by resulting in mildewing of foodstuff. *R*. *dominica* is difficult to control due to its characteristic of resistance to dryness and heat. This research aimed at selecting plants with greater bioactivity to *R*. *dominica*, and exploring the best botanical pesticide against this stored food pest.

1 MATERIALS AND METHODS

1.1 Materials

1.1.1 Botanicals: All the plant materials without any processing were purchased in June, 2005 at local Chinese traditional medicine markets in Wuhan City (Table 1).

Table 1 List of 20 medicinal plants tested for contact and repellency activities

Family name	Scientific name	Chinese name	Tissue used	Yields (%)
Amaryllidaceae	*Lycoris radiata*	Shisuan	Root	0.50
Araceae	*Acorus gramineus*	Shichangpu	Rhizome	8.91
Araceae	*Typhonium giganteum*	Baifuzi	Earthnut	5.15
Celastraceae	*Tripterygium wilfordii*	Leigongteng	Rhizome	7.33
Compositae	*Artemisia capillaries*	Yinchenhao	Seedling	12.85
Euphorbiaceae	*Croton tiglium*	Badou	Fruit	12.65
Lauraceae	*Litsea cubeba*	Shanjijiao	Fruit	10.20
Leguminosae	*Sophora flavescens*	Kusen	Rhizome	4.94
Leguminosae	*Trigonelia foenum-graecum*	Huluba	Seed	9.75
Liliaceae	*Veratrum nigrum*	Lilu	Rhizome	2.66
Phrymataceae	*Phryma leptostachya*	Tougucao	Stem	1.37
Polygonaceae	*Polygonum aviculare*	Bianxu	Rhizome	1.34
Ranunculaceae	*Aconitum carmichaeli*	Wutou	Rhizome	5.15
Saururaceae	*Houttuynia cordata*	Yuxingcao	The whole	6.25
Stemonaceae	*Stemona japonica*	Baibu	Rhizome	4.70
Thymelaeaceae	*Daphne genkwa*	Yuanhua	Flower bud	4.77
Umbelliferae	*Angelica pubescens*	Duhuo	Root	9.11
Umbelliferae	*Cnidium monnieri*	Shechuangzi	Seed	9.31
Zingiberaceae	*Alpinia officinarum*	Gaoliangjiang	Rhizome	6.32
Zingiberaceae	*Curcuma longa*	Huangjiang	Root	19.53

Yields = Dry weight of ethanol extracts/dry weight of test plant × 100

1.1.2 Insect culture: *Rhizopertha dominica* (Fab.) used in this research were obtained from stock cultures in our laboratory of Urban Pest Control, Huazhong Agricultural University, China. The insects have been maintained on disinfested whole wheat in 750 mL glass jars held at (28 ± 2) ℃, (70 ± 5) % relative humidity. Cultures of this pest were maintained in the laboratory in the dark without exposure to any insecticides.

1.2 Experiment methods

1.2.1 Preparation of plant extracts: The plant materials were first dried in the oven at 45℃. Then it was allowed to cool in the drying cabinet, ground to powder using Kenwood blender and later passed through a 50 μm mesh. Amount of 200 g dry plant powders was weighed and put into 1 000 mL bottle, and 500 mL ethanol was poured into the bottle, which was left to stand for 72 h at 25℃ in shady condition. The mixture was filtered, 300 mL of ethanol was added to the sediment, and the sediment was soaked for 48 h again. After 48 h, it was filtered again, and the later procedure was then repeated one more time. All filtrates were collected and concentrated in the rotary evaporation machine. The yield of each ethanol extract is given in Table 1. The extracts thus collected were oily and creamy, and kept in 100 mL brown bottles and preserved in refrigerator at 4℃ till being used.

1.2.2 Insect bioassay: Contact toxicity: The drug-film method was adopted (Wang *et al*., 2005). Every 1 g crude extract obtained from 1.2.1 above was diluted to 100 mg/mL using acetone, and the selected plants extracts were diluted to 25 mg/mL using acetone for further bioassay. To a clean Petri dish (9 cm diameter × 1.5 cm high), 1 mL extract solution was poured, the dish was then shaken gently until the solution formed a film, and the solution was left for some minutes to evaporate. Then 30 two-weeks old *R*. *dominica* adults were introduced into the Petri-dish and covered with net-lid. Two concentrations of each plant extract were used corresponding to 1.57 mg/cm^2 and 0.39 mg/cm^2. Each concentration was replicated 3 times, with acetone only without plant extract acting as the control. All of treatments were kept in insect bioassay room at (28 ± 2) ℃, (70 ± 5) % relative humidity, 16∶8 light: dark photoperiod, and mortality were counted after 24, 48, and 72 h.

Repellency efficacy: Filter paper diffusion method was adopted (Yao *et al*., 2005). Every 1 g crude extract obtained from 1.2.1 above was diluted to 100 mg/mL using acetone, and the selected plants extracts were diluted to 25 mg/mL using acetone for further bioassay. A 9 cm diameter filter paper was cut into two halves. Then 0.5 mL extract solution was dropped into a half of filter paper, and 0.5 mL acetone into the other half. The concentrations in the half filter paper of above two concentrations were 1.57 mg/cm^2 and 0.39 mg/cm^2 accordingly. After the acetone volatilized, the two halves of filter papers were joined together with adhesive tape to form the original shape and then put into the Petri dish. Thirty *R. dominica* adults of 2 weeks old were transferred into the dish and covered with net-lid. Each concentration was prepared in triplicate. Samples were held at (28 ± 2)℃, (70 ± 5)% relative humidity, and 16L∶8D photoperiod. The numbers of the adults present on the control (Nc) and treated (Nt) areas of the discs were recorded after 24, 48, and 72 h.

Percentage repellency (PR) values were computed as follows:

$$PR = [(N_c - N_t)/N_c] \times 100$$

The mean repellence value based on 1.57 mg/cm^2 at 72 h post-treatment was assigned to repellency classes (Juliana and Su, 1983) from 0 to Ⅴ: class 0 (PR < 0.1%), class Ⅰ (PR = 0.1% – 20%), class Ⅱ (PR = 20.1% – 40%), class Ⅲ (PR = 40.1% – 60%), class Ⅳ (PR = 60.1% – 80%), and class Ⅴ (PR = 80.1% – 100%).

Contact toxicity of *T. foenum-graecum*, *A. gramineus* and *C. monnieri* extracts: The method of bioassay is similar to "Contact toxicity" described in 1.2.1 but five concentrations (13.00, 6.50, 3.25, 1.63, 0.81 mg/mL) were used with a corresponding dosage of 204.5, 102.3, 51.1, 25.6, 12.8 μg/cm^2 per Petri dish respectively. Insect mortality was observed after 24, 48, and 72 h post-treatment, and the LD$_{50}$ of the plants extracts were obtained.

1.2.3 Statistical analysis: All data obtained from contact toxicity and repellence tests were first transformed to arcsine square-root values and then analysed using analysis of variance. Means were compared and separated by Scheffe's test at the $P = 0.05$ level (Tang and Feng, 1997). Means within a column followed by the same letter are not significantly different at $P = 0.05$. Means ($\pm SE$) of untransformed data are reported.

2 RESULTS

2.1 Contact efficacy of ethanol extracts from 20 plants against *R. dominica*

Table 2 Contact efficacy from 20 plants extracts against *Rhizopertha dominica* adults at 1.57 mg/cm^2

Tested material	Mortality (%, mean ± *SE*)		
	24 h	48 h	72 h
Aconitum carmichaeli	40.0 ± 5.1 def	50.0 ± 1.9 def	53.3 ± 1.9 de
Acorus gramineus	96.7 ± 7.7 ab	100.0 a	100.0 a
Alpinia officinarum	83.3 ± 2.6 abcd	86.7 ± 5.3 abc	93.3 ± 4.0 ab
Angelica pubescens	66.7 ± 5.5 bcde	70.0 ± 5.7 cde	80.0 ± 4.3 bcd
Artemisia capillaries	83.3 ± 5.2 abcd	90.0 ± 3.2 abc	93.3 ± 6.3 ab
Cnidium monnieri	96.7 ± 7.7 ab	100.0 a	100.0 a
Croton tiglium	83.3 ± 2.6 abcd	90.0 ± 5.3 abc	96.7 ± 7.7 ab
Curcuma longa	10.0 ± 3.2 fg	23.3 ± 4.6 gh	30.0 ± 5.5 e
Daphne genkwa	10.0 ± 3.2 fg	36.7 ± 2.0 efg	50.0 ± 1.9 de
Houttuynia cordata	96.7 ± 7.7 ab	96.7 ± 7.7 ab	100.0 a
Litsea cubeba	83.3 ± 8.1 abc	90.0 ± 3.2 abc	93.3 ± 3.2 ab
Lycoris radiata	30.0 ± 5.5 efg	33.3 ± 2.1 fg	53.3 ± 3.3 cde
Phryma leptostachya	80.0 ± 4.3 abcd	83.3 ± 5.2 bcd	86.7 ± 2.8 b
Polygonum aviculare	50.0 ± 5.1 cdef	86.7 ± 0.0 abc	96.7 ± 7.7 ab
Sophora flavescens	80.0 ± 4.8 abcd	86.7 ± 5.3 abc	90.0 ± 6.8 ab
Stemona japonica	73.3 ± 5.9 bcde	80.0 ± 4.3 bcd	83.3 ± 2.6 bc
Trigonelia foenum-graecum	100.0 a	100.0 a	100.0 a
Tripterygium wilfordii	3.3 ± 7.7 g	10.0 ± 3.2 gh	23.3 ± 3.8 ef
Typhonium giganteum	90.0 ± 5.3 abc	93.3 ± 4.0 abc	96.7 ± 7.7 ab
Veratrum nigrum	83.3 ± 6.6 abc	93.3 ± 11.0 abc	100.0 a
Control	2.2 ± 6.1 g	3.3 ± 7.7 h	4.4 ± 2.6 f

Result represents the mean of three replications, each set up with 30 adults ($n = 90$). The same for the following tables.

The ethanol extracts from 20 plants were tested for their contact efficacy to *R. dominica* by the drug-film method at 1.57 mg/cm^2 (Table 2). Significant differences in toxicity of the test materials to the adults were observed. Extract of *T. foenum-graecum* rapidly gave 100% mortality within 24 h after treatment. The extracts of *A. gramineus* and *C. monnieri* showed 100% mortality after 48 h treatment，and the extracts of *H. cordata* and *V. nigrum* gave 100% mortality within 72 h after treatment. Although the mortality of *T. giganteum* extract against the adults was lesser than the mortality of *V. nigrum* extract after 72 h treatment，the efficacy of *T. giganteum* extract was faster than the *V. nigrum* extract within 24 h treatment.

Table 3　Contact efficacy of selected plants extracts against *Rhizopertha dominica* adults at 0.39 mg/cm^2

Tested material	Mortality（%，mean ± *SE*）		
	24 h	48 h	72 h
Acorus gramineus	76.7 ± 2.3 b	83.3 ± 2.6 b	93.3 ± 4.0 b
Cnidium monnieri	80.0 ± 4.3 ab	90.0 ± 3.2 b	93.3 ± 6.3 b
Houttuynia cordata	30.0 ± 5.5 c	36.7 ± 2.0 c	50.0 ± 3.3 c
Trigonelia foenum-graecum	93.3 ± 4.0 a	100.0 a	100.0 a
Typhonium giganteum	80.0 ± 4.8 ab	83.3 ± 4.7 b	86.7 ± 5.3 b
Control	2.2 ± 6.1 d	3.3 ± 7.7 d	4.4 ± 2.6 d

Plant materials showing over 89.9% mortality at 1.57 mg/cm^2 after 24 h treatment against the *R. dominica* adults were tested at 0.39 mg/cm^2 for their insecticidal activity，and these selected plants for further bioassay accordingly were *T. foenum-graecum*，*A. gramineus*，*C. monnieri*，*H. cordata* and *T. giganteum*（Table 3）. From the observed values in Table 3，extract of *T. foenum-graecum* appeared to have the highest contact toxicity on adult *R. dominica*，and gave the 100% mortality at 0.39 mg/cm^2 within 48 h after treatment. *C. monnieri* extract gave 90.0% mortality within 48 h after treatment，and the *A. gramineus* extract gave 93.3% mortality within 72 h after treatment.

2.2　Repellence efficacy of ethanol extracts from 20 plants to *R. dominica*

The repellency of 20 plant extracts at 1.57 mg/cm^2 to the adult *R. dominica* is represented in Table 4. *Aconitum carmichaeli* has marked repellency on the pest，which showed 96.5% mean repellency within 24 h after treatment，followed by *C. monnieri*，*P. aviculare*，and *D. genkwa* in order. The plant extracts showing over 80% mean repellency within 48 h after treatment were *A. carmichaeli*，*C. monnieric*，*D. genkwa*，*P. aviculare*，*A. officinarum*，*C. tiglium*，and *A. gramineus* accordingly. Within 72 h after treatment，the plants *A. carmichaeli*，*C. monnieric*，*A. pubescens*，*C. tiglium*，and *D. genkwa* showed over 70% mean repellency. The extracts from *A. capillaries*，*T. foenum-graecum*，*T. wilfordii*，and *T. giganteum* showed 0.0% repellency effects at 1.57 mg/cm^2 to *R. dominica* adult within 72 h after treatment.

Plant materials showing over 70% repellency efficacy at a dose of 1.57 mg/cm^2 after 72 h treatment were tested at 0.39 mg/cm^2 for further bioassay，and the selected plants accordingly are *A. carmichaeli*，*A. pubescens*，*C. monnieric*，*C. tiglium*，and *D. genkwa*（Table 5）. The extract of *C. monnieric* appeared to have the highest repellency on adult *R. dominica*，and gave 69.5% repellency value at 0.39 mg/cm^2 within 24 h after treatment，followed by *A. carmichaeli* and *C. tiglium* extracts. The *A. pubescens* and *D. genkwa* extracts showed weak repellency to the pest with 0.0% repellency after 72 h treatment.

2.3　Contact toxicity of ethanol extracts from *T. foenum-graecum*，*A. gramineus* and *C. monnieri* to adult *R. dominica*

Three ethanol extracts were prepared in five concentrations as described in 1.2.2 above，and were applied to determine its contact toxicity，LD$_{50}$ to *R. dominica* by drug-film method（Table 6）. The results showed that the *T. foenum-graecum* extract had better contact toxicity than *A. gramineus* and *C. monnieri* extracts. The order of potency of the three ethanol extracts to the pest based on the LD50 level was *T. foenum-graecum* > *C. monniei* > *A. gramineus*. At the same time，a comparison of the slopes of the dose-mortality relationships showed that *T. foenum-graecum* was more potent than *C. monnieri* and *A. gramineus* at higher doses against *R. dominica*.

3　DISCUSSION

The exploration and utilization of botanical pesticides generally has two ways at present. One way is the direct utilization，which means the crude extract from plant was processed to pesticide and utilized directly. The other way is the indirect utilization，which is to research the structure，action mechanism of effective compositions in plants，and then take the effective compositions for lead compounds to synthesize novel pesticides（Fu and Zhang，1996）. In the course of botanical pesticide research，there are some problems to be urgently resolved. For example，although insecticidal plants had been studied severally，most of research work was based on the stage of direct utilization，so the research of active component and action mechanism must be enhanced. The stability of botanical pesticides could be deficient，and their efficacy could be greatly affected by the environment during application. The effect of single application is very slow，so its effect is generally obtained through mixing or remixing with other pesticide（Du and Xu，2000）. Secondary metabolic substances of many plants were found to have varieties of biological activities including insecticidal activity against many insects without any adverse effects on most non-target organism（Saxena，1989；Lowery and Isman，1995）. Additionally，certain plant-derived compounds were found to be highly effective against insecticide-resistant insect pests（Arnason *et al*.，1989；Schmutterer，1992；Ahn *et al*.，1997）. With the constant progress of science and invention of precision instrument，the potential of botanical pesticides will be more and more promising（Xu *et al*.，2003）.

Table 4 Repellence efficacy of 20 plants extracts against *Rhizopertha dominica* adults at 1.57 mg/cm^2

Tested material	Repellency（%，mean ± *SE*）			Repellency class
	24 h	48 h	72 h	
Aconitum carmichaeli	96.5 ± 7.9 a	96.5 ± 7.9 a	92.8 ± 4.4 a	Ⅴ
Acorus gramineus	74.9 ± 3.5 ab	80.1 ± 13.3 abc	63.5 ± 3.7 abc	Ⅳ
Alpinia officinarum	75.0 ± 12.7 ab	88.8 ± 3.8 abc	63.5 ± 3.7 abc	Ⅳ
Angelica pubescens	79.9 ± 3.5 ab	75.0 ± 12.7 abc	75.0 ± 12.7 ab	Ⅳ
Artemisia capillaries	0.0 c	0.0 e	0.0 d	0
Cnidium monnieri	88.8 ± 3.8 a	92.8 ± 4.4 ab	75.0 ± 0.0 ab	Ⅳ
Croton tiglium	79.8 ± 18.6 ab	88.1 ± 3.8 abc	75.0 ± 12.7 ab	Ⅳ
Curcuma longa	57.1 ± 0.0 ab	75.0 ± 12.7 abc	33.2 ± 16.7 bcd	Ⅱ
Daphne genkwa	80.1 ± 13.3 ab	92.1 ± 4.4 ab	74.9 ± 3.5 ab	Ⅳ
Houttuynia cordata	69.5 ± 12.8 ab	57.3 ± 12.7 abcd	63.6 ± 0.0 abc	Ⅳ
Litsea cubeba	50.1 ± 14.2 abc	63.5 ± 3.7 abcd	33.2 ± 16.7 bcd	Ⅱ
Lycoris radiata	50.1 ± 13.0 abc	56.9 ± 4.0 abcd	33.3 ± 0.0 bcd	Ⅱ
Phryma leptostachya	50.1 ± 14.2 abc	42.1 ± 0.0 cd	12.5 ± 0.0 cd	Ⅰ
Polygonum aviculare	84.4 ± 14.1 ab	88.9 ± 3.8 abc	50.1 ± 14.2 abc	Ⅲ
Sophora flavescens	75.0 ± 12.7 ab	63.5 ± 3.7 abcd	63.5 ± 3.7 abc	Ⅳ
Stemona japonica	12.5 ± 0.0 bc	49.9 ± 0.0 bcd	12.5 ± 0.0 cd	Ⅰ
Trigonelia foenum-graecum	63.5 ± 3.7 ab	50.1 ± 14.2 bcd	0.0 d	0
Tripterygium wilfordii	0.0 c	0.0 e	0.0 d	0
Typhonium giganteum	0.0 c	0.0 e	0.0 d	0
Veratrum nigrum	50.1 ± 14.2 abc	12.5 ± 0.0 de	56.9 ± 4.0 abc	Ⅲ

Table 5 Repellence efficacy of selected plants extracts against *Rhizopertha dominica* adults at 0.39 mg/cm^2

Tested material	Repellency（%，mean ± *SE*）		
	24 h	48 h	72 h
Aconitum carmichaeli	50.1 ± 14.2 ab	41.8 ± 4.9 ab	33.2 ± 16.7 a
Angelica pubescens	12.5 ± 0.0 b	23.5 ± 7.3 b	0.0 b
Cnidium monnieri	69.5 ± 12.8 a	49.8 ± 4.3 a	33.0 ± 5.7 a
Croton tiglium	23.5 ± 0.0 b	33.0 ± 5.7 ab	23.1 ± 7.3 a
Daphne genkwa	23.1 ± 7.3 b	33.3 ± 0.0 ab	0.0 b

Table 6 Contact toxicity of three ethanol extracts to *Rhizopertha dominica* adults after 72 h treatment

Tested material	Regression equation of toxicity	LD$_{50}$（μg/cm^2）	95% fiducial limits（μg/cm^2）	Relative-Coefficient（r）	Chi-Square（χ^2）	Significance（P）
Acorus gramineus	$y = 1.4110 + 2.4717x$	28.32	10.39 – 44.59	0.9732	12.83	0.0050
Cnidium monnieri	$y = 1.5602 + 2.5215x$	23.13	18.44 – 27.53	0.9787	10.56	0.0144
Trigonelia foenum-graecum	$y = 1.0855 + 3.0116x$	19.94	2.80 – 33.31	0.9534	13.78	0.0032

From the results obtained in the contact and repellence efficacy of ethanol extracts from 20 plants tested in this research，it could be concluded that the *T*. *foenum-graecum* has marked contact toxicity on *R*. *dominica*. The *A*. *gramineus* and *C*. *monnieri* have better contact efficacy to adult *R*. *dominica*. As for the repellency potential，the extract of *C*. *monnieri* has excellent effect on the insect pest，and the extracts of *A*. *carmichaeli* and *C*. *tiglium* have better repellency. The *C*. *monnieri* extract has better contact and repellence efficacy. The extracts of several plants have little efficacy on this pest. There are several reasons for this result. Firstly，these plants might not contain the active substance toxic to the test insect. Secondly，though these plants may contain active toxic substance，perhaps these toxic compounds could not be extracted by ethanol. Thirdly，the amount of active components might be very small.

For many years，*T. foenum-graecum* has been explored and utilized as a sort of traditional medicinal and industrial material，and sometimes as a simple parasiticide，but there are few reports on its pontential use as an insecticide. Through the results obtained in this present study，it was generally observed that this plant had favourable contact toxicity to *R. dominica*，thereby providing a certain theoretical basis for further exploration and utilization of *T. foenum-graecum* in stored pest control. Owing to the fact that *T. foenum-graecum* plant is edible and non-toxic to human and livestock，this plant could therefore be used to control stored pest and incorporated into Integrated Pest Management（IPM）. In order to optimize its bioactivity potential，the efficacy of *T. foenum-graecum* should also be tried on other stored and agricultural pests. Besides the direct contact and repellency efficacy，its effect on normal growth，fecundity，oviposition and population growth should be researched，and the active ingredient should be further researched as well.

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20 种药用植物乙醇提取物对谷蠹的触杀和驱避活性

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摘要：采用药膜法和滤纸药膜选择法，分别研究了 20 种药用植物乙醇提取物对谷蠹 *Rhizopertha dominica* （Fab.）成虫的触杀和驱避活性。结果表明：触杀效果以葫芦巴 *Trigonelia foenum-graecum* 提取物的活性最强，蛇床子 *Cnidium monnieri* 和石菖蒲 *Acorus gramineus* 提取物次之。葫芦巴提取物 0.39 mg/cm^2 浓度处理 48 h 后对谷蠹的触杀死亡率为 100%，处理 72 h 后对谷蠹的 LD_{50} 为 19.94 μg/cm^2。蛇床子和乌头 *Aconitum carmichaeli* 提取物对谷蠹成虫具有显著的驱避活性。蛇床子提取物同时具有较好的触杀和驱避活性。

关键词：植物提取物；触杀；驱避；谷蠹；葫芦巴
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